Thomas Exhibit 1

UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

LAFARGE CANADA INC. and LAFARGE NORTH AMERICA, INC., Plaintiffs,	:	
v.	:	15-CV-8957 (RA)
AMERICAN HOME ASSURANCE COMPANY, AIG INSURANCE COMPANY OF CANADA, and LEXINGTON INSURANCE COMPANY, Defendants.	:	

EXPERT REPORT OF DR. MICHAEL THOMAS

March 20, 2017

TABLE OF CONTENTS

GLOSSARY

Term	*Definition*
AAR	Acronym for alkali-aggregate reaction (see below)
ACR	Acronym for alkali-carbonate reaction (see below)
Alkali-aggregate reaction	A reaction that occurs between the alkalis from Portland cement and certain aggregates that can, under certain circumstances, lead to expansion and cracking of concrete
Alkali-aggregate reactive	An adjective applied to an aggregate that is susceptible to alkali-aggregate reaction
Alkali carbonate reaction	A form of alkali-aggregate reaction that involves carbonate phases in the aggregate
Alkali-carbonate reactive	An adjective applied to an aggregate that is susceptible to alkali-carbonate reaction
Alkali-silica reaction	A form of alkali-aggregate reaction than involves silica phases in the aggregate
Alkali-silica reactive	An adjective applied to an aggregate that is susceptible to alkali-silica reaction
Alum shale	Black shale containing pyrite
ASR	Acronym for alkali-silica reaction (see above)
Basic igneous rock	An igneous rock with a silica content between 45 and 53%
Calcium-silicate-hydrate	A cement hydration product that contains calcium and silica with no single fixed composition but often approximated as $3CaO{\cdot}2SiO_2{\cdot}3H_2O$
Carbonation	A process that occurs in concrete when carbon dioxide (CO_2) from the atmosphere penetrates the concrete and reacts with the cement hydration products, particularly calcium hydroxide ($Ca(OH)_2$), to produce calcium carbonate ($CaCO_3$), thereby lowering the pH of the concrete and rendering it more acidic

Term	*Definition*
Cement hydration products	Solid products that are produced by the chemical reaction between cement and concrete; the products include calcium silicate hydrate (C-S-H), various calcium aluminate phases and calcium hydroxide ($Ca(OH)_2$)
Cement-stabilised minestone	A term in use in the U.K. that refers to a form of roller-compacted concrete produced using colliery spoil (minestone) as the aggregate
Chalcopyrite	An iron sulfide mineral containing copper ($CuFeS_2$)
Chloride ingress	The process by which chloride ions from seawater or deicer salts enter and penetrate in to concrete
Coarse aggregate	The larger aggregate particles in a concrete mix, typically greater than 3/8-inch (5-mm) in size, which may be gravel or crushed rock
Combined acid/sulfate attack	Attack on concrete by sulfuric acid (H_2SO_4)
C-S-H	Acronym for calcium-silicate-hydrate (see above)
Ferric oxyhydroxides	Hydrated iron hydroxide ($FeOOH{\cdot}nH_2O$)
Filler	Term used to describe a minor component that may be added to Portland cement; limestone is commonly used as a filler
Fine aggregate	The finer aggregate particles in a concrete mix, typically less than 3/8-inch (5-mm) in size, typically naturally-derived but may be manufactured by grinding larger aggregates
Fineness modulus	An index number calculated from a sieve analysis that provides an empirical indication of the fineness of a sand
Freeze-thaw damage	Damage that may be created when concrete is exposed to frequent cycles of freezing and thawing
Frost damage	Alternative term for freeze-thaw damage
Fully saturated	A term used to describe the condition when all of the pores in concrete are completely filled with water
Gneiss	A type of metamorphic rock

Term	*Definition*
Goethite	A ferric hydroxide with the chemical formula FeOOH
Granodioritic gneiss	A type of metamorphic rock
Heaving	A term used to describe the process when the underlying material beneath a structure swells and causes uplift of the structure
Igneous rock	Rock formed through the cooling and solidification of magma or lava; one of the three principal types of rocks, the other two being metamorphic and sedimentary rock
Internal sulfate attack	Deterioration process in concrete whereby sulfate minerals within the concrete attack the products of cement hydration, usually leading to expansion and cracking
Iron sulfides	Chemical compounds consisting of the elements iron (Fe) and sulfur (S) including pyrite (FeS_2) and pyrrhotite ($Fe_{1-x}S$)
ISA	Acronym for internal sulfate attack (see above)
Jarosite	A hydrous potassium iron sulfate mineral having the formula $KFe_3(SO_4)_2(OH)_6$
Laminar structure	Composed of fine layers
Limonite	A iron oxyhydroxides mineral with the generic formula FeO(OH)
Metamorphic rock	A rock that has been transformed by heat and pressure resulting in physical and/or chemical changes; for example, gneiss, quartzite, slate and marble; one of the three principal types of rocks, the other two being igneous and sedimentary rock
Micas	A group of minerals; sheet silicates
Minestone	Colliery spoil; shales and other rocks that are associated with coal during mining
Non-stoichiometric	Chemical compounds where the proportions for different elements cannot be represented by whole numbers

Term	*Definition*
Oxidation	The process when a compound becomes chemically combined with oxygen
Permeability	A measure of the ease with which fluids can pass through porous media
Phase	A substance that has a fixed composition and uniform chemical and physical properties, such as an element, a compound or a mineral
Porosity	The void space within a material
Portland cement	A basic ingredient in concrete that reacts with water and hardens providing strength to the concrete
Prism	In concrete, a test specimen with a rectangular cross section
PSI	Pounds per square inch
Pyrite	An iron-sulfide mineral consisting of iron (Fe) and sulfur (S) and having the chemical formula FeS_2
Pyritic	Related to or consisting of pyrite
Pyrrhotite	An iron-sulfide mineral consisting of iron (Fe) and sulfur (S) and having the chemical formula $Fe_{1-x}S$)
Reaction kinetics	The rate at which chemical reaction proceeds and the study of factors that affect that rate
Reactivity	The tendency of a substance to undergo chemical changes within a system
Reinforcement corrosion	The oxidation (rusting) of steel that is embedded in reinforced concrete
Reticulated	Characterized by or having the form of a grid or network.
Rust minerals	A generic term for the range of brownish/yellowish materials that form on the surface of iron or iron compounds when they are exposed to oxygen and water
Saturation	In concrete: the condition when all of the pore spaces are filled with water

Term	*Definition*
Sedimentary rock	Rock that has formed through the deposition and solidification of sediment, usually in layers; for example, limestone, sandstone and shale; one of the three principal types of rocks, the other two being igneous and metamorphic rock.
Spalling	In connection with concrete, disintegration in the form of lumps of material being detached from the bulk
Sphalerite	An iron sulfide mineral ((Zn,Fe)S) containing zinc
Sulfate attack	The process by which certain compounds of sulfate attack the products of cement hydration leading to expansion, cracking and, sometimes, loss of integrity
Thaumasite	A mineral with the chemical formula $2CaSiO_3 \cdot CaSO_4 \cdot CaCO_3 \cdot 15H_2O$ which may be produced in concrete as a result of sulfate attack
W/CM	In connection with concrete, the ratio, by mass, of water to cementing material

1.0 EXPERT QUALIFICATIONS AND ENGAGEMENT

1.1. Qualifications

I have been a Professor since 2002 and the Department Chair since 2014 in the Department of Civil Engineering at the University of New Brunswick (UNB). I have been a registered Professional Engineer in the Province of New Brunswick since 2002; prior to this I was a registered Professional Engineer in the Province of Ontario. My academic and commercial work has focused exclusively on cement and concrete research since I started my Ph.D. in 1983.

I was a faculty member at the University of Toronto from 1994 to 2002, immediately prior to joining UNB. Before 1994 I worked for two years as a concrete materials engineer with Ontario Hydro, Ontario's public electricity utility, which owned, operated and built extensive thermal, hydroelectric and nuclear electric generating facilities. Prior to joining Ontario Hydro I worked as a research fellow with the Building Research Establishment in the U.K., which was then an agency within the U.K. government charged with, among other things, conducting research as to the built environment and building materials.

I am also the President and founder of C&CS Atlantic Inc., a consulting firm that provides professional services, including expert advice and expert testimony in litigation, in the areas of concrete materials and their durability and rehabilitation.

I received a B.Sc. in Civil Engineering from the University of Nottingham, U.K., in 1982, and a Post-Graduate Certificate of Education from the same institution in 1983. I received a Ph.D. in Civil Engineering from Aston University, U.K., in 1987; the title of my thesis was *The Performance of Cement-Stabilised Minestone*. My graduate work was focused on determining the cause of failure in pavements constructed using cement-stabilised minestone (CSM).[1] This involved the forensic analysis of numerous roller-compacted concrete (RCC) pavements and laboratory studies to investigate the cause of failure and to determine measures to prevent deterioration in future construction. In the course of this work I determined that the cause of failure of these pavements was oxidation of pyrite in the minestone, which resulted in expansion and internal sulfate attack (ISA) on the cement hydration products.

Much of my research and consulting work has involved the investigation and evaluation of concrete structures including pavements, bridges, large hydraulic dams and house foundations. I have frequently been engaged to conduct forensic evaluations to determine the cause of premature failure of concrete structures due to deterioration processes such as sulfate attack (internal and external), reinforcement corrosion (due to carbonation or chloride ingress), frost damage and alkali-aggregate reaction (AAR). I have conducted laboratory-based research on all of these durability issues for the past 30 years, resulting in more than 200 technical publications in peer-reviewed journals or conference proceedings.

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[1] In addition to my thesis, the research resulted in two publications in peer-reviewed journals (Appendix A, A108 and A109) and three papers published in conference proceedings (Appendix A, C94 to C96).

I am an active member of the following standards and research committees of the indicated professional organizations in the indicated capacity:

Capacity	*Professional Organization*	*Committee*	*Years of Service*[2]
Voting Member	Canadian Standards Association (CSA)	Technical Committee A3000 *Cementitious Materials*	25
Voting Member	Canadian Standards Association (CSA)	Technical Committee A23.1/A23.2 *Concrete Materials and Methods of Concrete Construction/Methods of Test for Concrete*	23
Voting Member	Canadian Standards Association (CSA)	Technical Sub-Committee on *Aggregate Reactions*	25
Chair; Member	American Concrete Institute (ACI)	201 Task Group on *Alkali-Aggregate Reactions* (formed in 2014)	3
Member	American Concrete Institute (ACI)	Various Technical Committees	[25]
Voting Member	American Society for Testing and Materials (ASTM)	Technical Committee C-01 *Cement*	[20]
Voting Member	American Society for Testing and Materials (ASTM)	Technical Committee C-09 *Concrete and Aggregates*	[20]
Voting Member	Reunion Internationale des Laboratoires et Experts des Materiaux, Systemes de Construction et Ouvrages[3]	Technical Committee on *Alkali-Aggregate Reactions*	[10]

My *curriculum vitae*, which includes a list of all publications I have authored in the previous 10 years, is attached in Appendix A.

1.2. Compensation

My consulting fee for serving as an expert witness in this case is USD $300 per hour. My compensation is not contingent on my findings, opinions or conclusions.

2 Complete records of my service are not available for all committees listed, and where necessary I have supplied an estimate of the number of years of my service, as indicated by brackets.

3 I.e., RILEM, or the International Union of Laboratories and Experts in Construction Materials, Systems, and Structures.

1.3. Prior Expert Work

As of the date of this Report, I have testified at trial as an expert on the subject of cement and concrete materials in three litigations in the United States and Canada. I have been deposed approximately six times, including in each of the three cases that went to trial. I have also provided expert opinion reports in numerous cases that settled before it was necessary for me to be deposed or to testify.

These cases have included allegations of, among other things: (i) severe deterioration (disintegration) of residential foundations due to internal sulfate attack resulting from the incorporation of an unsuitable material as a partial replacement for Portland cement; (ii) alkali-aggregate reaction in a residential exposed-concrete slab; (iii) deterioration of concrete rail tunnels due to inundation by Superstorm Sandy; (iv) construction delays with slip-formed caissons; and (v) pop-outs in masonry blocks. In most of these cases, my role has included forensic evaluation to determine the cause of deterioration or problem and recommended remediation.

Through my consulting work, including engagements as an expert witness, I have frequently encountered circumstances where concrete-making materials have been evaluated and certified as suitable for use in the production of concrete or where concrete mixture designs have been evaluated and certified for use in a particular construction. Such studies frequently involve the review and analysis of test data and comparison with the requirements of the specification in force for that jurisdiction.

The only deposition or trial testimony I have given during the previous four years was in the following case:

- *National Railroad Passenger Corporation v. Arch Specialty Insurance Company, et al.*, No. 14-cv-7510 (JSR) (S.D.N.Y.)

1.4. Source Materials and References

In reaching my opinion I relied on court filings, testimony, and discovery materials, as well as publications such as technical papers, books and newspaper articles. A full list of the documents on which I relied is provided in Appendix B.

2.0 SUMMARY

2.1. Concrete, Its Function, and Its Defects

Concrete is the most widely used construction material in the world. It is used for all manner of construction from residential foundations (e.g. footings, floors and walls) through commercial and industrial buildings, sidewalks and high-rise construction to public utilities and major civil infrastructure such as pavements, bridges, tunnels, dams and harbor works. Essentially, concrete consists of aggregates (crushed rock, gravel and sand) that are bound together by a mixture of cement (a binding agent) and water. A wide range of concrete properties can be achieved by changing the materials and, in particular, the relative proportions of these materials in a given mixture. For example, the compressive strength of concrete, which is used as the industry standard for gauging concrete quality, might vary from 2,500 PSI for typical concrete used in a residential foundation wall, to up to 20,000 PSI for high-strength concrete used in high-rise construction (skyscrapers).

Most concrete produced worldwide utilizes Portland cement as the principal cementing material. Portland cement is manufactured by firing raw materials (predominantly limestone and clay) in a rotary kiln at a temperature of approximately 2,650 degrees Fahrenheit and then grinding the resulting material to a fine powder.

When its ingredients are initially mixed together, concrete is a fluid material that can be formed into a variety of shapes and components. There is a chemical reaction between the cement and the water, termed hydration, which causes the cement paste to harden over time, transforming the once fluid material into a hardened solid capable of bearing loads. Although, typically, concrete gains sufficient strength to be put into service after a few days or weeks, the longer-term continued hydration of the cement results in gradual improvements in the properties (e.g. increased strength and reduced porosity) of the concrete over time.

"Cement hydration products" are products resulting from the chemical reaction (hydration) of Portland cement with water. These include various calcium phases (i.e., calcium-containing compounds and minerals) such as calcium-silicates, calcium-aluminates and calcium hydroxide.

Modern concrete mixtures may contain a wide variety of different cementing materials and a range of chemical admixtures that can improve the performance of the concrete in both the fresh and hardened state.

The strength and durability of concrete depend to a large degree on the component materials and the proportions of these materials. One of the main factors that affects these properties is the water-to-cementing-materials ratio (W/CM); as the W/CM is reduced the strength of the concrete increases and, generally, other properties, including durability, are improved.

Normally, concrete is a durable material and, provided the proper attention is paid to the selection of materials and the proportions used to produce the concrete, concrete structures can serve their function for many decades or even centuries, even when exposed to extreme conditions in service. There are a number of chemical and thermal processes that can result in the

premature deterioration of concrete structures if they are not properly designed and/or constructed. The most common forms of deterioration encountered in North America are frost attack caused by repeated cycles of freezing and thawing, problems related to the chemical instability of the aggregates and, in the case of reinforced concrete, corrosion of the steel reinforcement embedded in the concrete due to the penetration of deicer salts or seawater.

Some aggregates undergo chemical reactions when used in concrete in some circumstances. The most commonly encountered reactions of this type are alkali-aggregate reactions (AAR); these are further divided into alkali-silica reactions (ASR) and alkali-carbonate reactions (ACR). ASR has occurred widely throughout Canada, the United States and worldwide. The reaction occurs when alkali hydroxides (NaOH and KOH)[4] originating from the cement react with certain silica (SiO_2) minerals found in some aggregates. The reaction can, under certain circumstances, lead to expansion and cracking of the concrete. In extreme cases, ASR may necessitate replacement of the concrete.

ACR is similar to ASR, but the reactive phases in ACR are certain carbonate phases found in some aggregates (as opposed to silica phases as is the case for ASR). ACR has been observed only in a few locations in North America.

Another form of potentially deleterious reactions is the oxidation of sulfide minerals in some aggregates. Incidences of this type of deterioration are far scarcer than either type of AAR and, prior to 2002, were limited to a few isolated occurrences worldwide. It is this reaction and its accompanying form of deterioration that has resulted in the property damage, both actual and alleged, at issue in the underlying Trois-Rivières litigation.

[redacted]

Beginning in 2008, it was reported that a large number of concrete foundations in residential and commercial buildings in the Trois-Rivières area were exhibiting a similar form of deterioration

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4 Throughout this report, for both convenience and the sake of definiteness, I have inserted in parentheses the chemical formulas for materials that I reference.

5 [redacted]

that has also been attributed to the same phenomenon, although in most cases reported in the professional literature the source of the coarse aggregate was the B&B Quarry in St. Boniface, Québec, which neighbors the Maskimo Quarry. The foundations of these buildings were primarily placed (i.e., formed and poured) during the period 2003 to 2007, with reports of problems starting as early as 2008 and continuing until the current time. [redacted]

2.2. The Trois-Rivières Litigation

Since the discovery of these damaged foundations in structures in the Trois-Rivières region, hundreds of home and building owners have filed claims against home builders, concrete suppliers and others. In February 2012, the court having jurisdiction over most of these claims consolidated proceedings for claims filed between 2009 and 2012 that were trial-ready; this was termed the "first wave" of claims. Other claims, including those filed after February 2012, form a "second wave" of claims.

Beginning in October, 2012, Lafarge Canada Inc. (Lafarge) and its employee, Marie de Grosbois, were named as third party defendants by some of the defendants in these claims, including an independent consulting and testing organization, SNC Lavalin, and various concrete suppliers. Soon afterwards Lafarge and Ms. de Grosbois were also named as direct defendants by some of the second-wave claimants.

It has been alleged by the parties asserting claims against Lafarge that Lafarge and Ms. de Grosbois erroneously stated to one of the concrete-supplier defendants, Béton Laurentide, that B&B Quarry aggregate was suitable for use in concrete. The basis for this allegation centers on Lafarge conducting a total sulfur analysis of a sample of B&B Quarry aggregate in February 2002 and a subsequent telephone conversation between a principal of Béton Laurentide, Michel Bergeron, and Ms. de Grosbois concerning the analysis. There is a disagreement among the parties to the underlying Trois-Rivières litigation concerning the substance of that telephone conversation. During later periods, Lafarge and Ms. de Grosbois are also alleged to have failed to warn of the risks associated with the use of the B&B Quarry aggregate.

I understand that the defendant insurers in this insurance coverage litigation contend that Lafarge's role constitutes the provision of a professional service, as that phrase is used in the relevant policies, and that, as such, coverage for Lafarge's potential liability in the Trois-Rivières litigation under umbrella policies issued by two of the Defendants could be barred by a "professional services" exclusion in those policies on the purported grounds that Lafarge's conduct constituted the provision of professional services or the failure to provide professional services that were due.

2.3. Subject of this Report

This Report addresses the two following specific matters:

1. [redacted]

2. *Professional Services:* This Report evaluates whether alleged conduct of Lafarge and its employees between February 2002 and September 2005, on which allegations of Lafarge's liability in the underlying Trois-Rivières litigation are based, constitute professional services or failure to provide professional services in the areas of concrete engineering, civil engineering, geology or any other relevant professional discipline.

2.4. Expert Opinion—Summary

As explained in detail in the remainder of this Report, my opinions are as follows:

1. [redacted] The rate of oxidation of pyrrhotite in a concrete structure and the rate of subsequent internal sulfate attack on the cement hydrates within is dependent on a wide range of parameters including (a) the composition and properties of the aggregate utilized in the structure, (b) the composition and proportions of the concrete mixture utilized in the structure, and (c) the nature of the structure's history of exposure to environmental conditions, including, most importantly, temperature and the availability of moisture and oxygen. [redacted]

2. *Professional Services:* [redacted] My further opinion is as follows:

a. [redacted]

b. [redacted]

c. [redacted]

d. [redacted]

[redacted] In my experience, no professional service provider in this area would offer a casual, unwritten, uncertified recommendation concerning suitability of a source of aggregate to be used in concrete, and particularly not on the basis of a total sulfur test alone. Similarly, based on my experience, no consumer of professional services in this area would expect a recommendation communicated in this manner or decide to use a source of aggregate on the basis of such a communication. Where professional services are rendered concerning the suitability of aggregate, professional services providers provide and clients expect recommendations in written, certified reports describing the methodology employed, setting forth and discussing the findings, and including caveats and other considerations. An example of one type of such a certified report, a certified petrographic analysis, is attached as Appendix D.

e. [redacted] In my experience, professional services providers in this area never render recommendations concerning the suitability of aggregates in this manner—that is, declining to respond to a message is not tantamount to an implicit professional endorsement that a particular aggregate is safe to use. Nor have I ever encountered a client for whom this would be a sufficient basis on which to make a decision to use a source of aggregate in concrete. In my opinion, which is based on decades of experience in the field, professional service firms in the area of construction aggregates provide, and clients expect, written recommendations based upon thorough testing.

3.0 BACKGROUND FACTS

3.1. [redacted]

[redacted] [redacted]

[redacted]

[redacted]

[redacted]

[redacted] [redacted]

[redacted]

[redacted] [redacted]

[redacted] [redacted]

[redacted]

[redacted] [redacted]

[redacted]

[redacted]

[redacted] [redacted]

[redacted]

[redacted] [redacted]

[redacted]

[redacted]

[redacted] [redacted]

[redacted]

[redacted]

Figure 1 Photographs of House Foundation in Eastern Connecticut (June 2016)

[redacted]

[redacted]

3.1.2. [redacted]

[redacted]

- [redacted]
- [redacted]
- [redacted]
- [redacted]

[redacted]

- [redacted]

- [redacted]

- [redacted]

- [redacted]

3.1.3. <u>Trois-Rivières Case</u>

[redacted]

[redacted]

[redacted]

The most comprehensive data (including visual condition and chemical/mineralogical composition of the concrete) on the damage alleged in the Trois-Rivières Litigation that was available to me was the "Final Report" from Golders (2011),[7] which includes an analysis for up to 335 homes that were investigated by the "Panel of Experts" for the defendants. The data available for these homes included:

[redacted]

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7 This report, dated November 10, 2011, was produced by Golder and Associates for their clients Lavery, de Billy L.L.P. *See* LAF0000035717.

- Damage Rating (visual condition rating developed by the Panel of Experts) ranging from Rating 0 for no significant damage to Rating 3 for extensive damage (see Table 1);
- Time elapsed between construction and the observation of damage;
- Average sulfur content of the concrete (% S by mass of concrete);
- "Inferred" average sulfur and pyrrhotite in coarse aggregate (% by volume); and
- The proportion of houses (%) in each category (visual condition rating).

[redacted]

Table 1 Visual Condition Rating Developed by Panel of Experts

Rating	*Observations*
0	• No crack in the concrete wider than 0.1 mm or longer than 150 mm; • No polygonal crack patterns in the concrete; • Some vertical cracks, likely attributed to shrinkage; and, • Some cracks at windows
1	• Presence of horizontal cracks in the concrete that are wider than 0.1 mm or at least 150 mm long; • Presence of polygonal crack patterns (crack width at least 0.5 mm) on a maximum of two walls; and, • General damage on less than 25% of all surfaces.
2	• Presence of a well-developed polygonal crack pattern with crack openings >0.5 mm on a maximum of two walls; • May have polygonal cracking on other walls; • May have horizontal cracking; and, • General damage on less than 50% of all surfaces
3	• Presence of a well-developed polygonal crack pattern with crack openings >0.5 mm on more than two walls; • May have horizontal cracking; and, • General damage on more than 50% of all surfaces

A visual rating of 0 (zero) basically indicates that no significant damage has occurred to date; in other words, the extent of visible damage is de minimis and what might be found in a typical,

structurally sound residential foundation. [redacted]

More than 60% of the structures for which Golders reported an Inspection Rating of 0 were found, by means of taking cement cores, to have sulfur content in the range of 0.42% to 0.65% S by mass of concrete (classified as “medium” by the Panel of Experts) or greater (i.e., more than 0.65% S by mass of concrete) (classified as “high” by the Panel of Experts). [redacted]

[redacted]

- [redacted]
- [redacted]
- [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

8 [redacted]

3.2. Evaluation of Aggregates for Use in Concrete

Aggregates make up between 60 to 75% of the volume of a typical concrete mix and, both as a matter of logic and as long experience has taught, the properties of aggregates are important to ensure proper performance of the concrete.

3.2.1. Tests for Evaluating Aggregates for Concrete

The evaluation of aggregates to determine their suitability for use in concrete requires an onerous and comprehensive suite of tests that are usually (a) conducted by a certified laboratory; (b) documented in one or more reports setting forth the results and containing one or more certificates of conformance; and (c) issued with the approval (usually including the seal) of a professional engineer or geologist.[9]

To illustrate the extensive scope of the required testing, the requirements of Canadian Standards Association (CSA),[10] which exceed 300 pages in length, are summarized here as follows :

1. Grading (particle-size distribution, psd) determined by sieve analysis (CSA A23.2, Test 2A); results must fall between certain limits (CSA A23.1, Tables 4 and 5);

2. Particle shape (coarse aggregate only)—to eliminate flat and elongate particles (CSA A23.2, Test 13A);

3. Fineness modulus must fall within certain limits (CSA A23.1, Table 4) for fine aggregate;

4. Uniformity; limit on the amount of variability of the fineness modulus (CSA A23.1, Clause 5.3.2.3);

5. Inorganic impurities; determined using a color value (fine aggregate only);

6. Alkali-aggregate reactivity (AAR); aggregates tested to determine reactivity (CSA A23.2, Test 14A and/or 25A); alkali-silica reactive (ASR) aggregates can be used with appropriate preventive measures (CSA A23.2, Test 27A) but alkali-carbonate reactive aggregates must NOT be used in concrete;

7. Other reactions standard (CSA A23.1, Clause 5.5.2), which warns against aggregates that may cause expansion because of reasons other than AAR; this includes sulfides such as pyrite, pyrrhotite and marcasite, sulfates such as

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[9] An example of a certified petrographic analysis, which is one part of a suitability report, is attached as Appendix D.

[10] These tests have been compiled from CSA A23.1 *Concrete Materials and Methods of Concrete Construction* and CSA A23.2 *Methods of Test for Concrete* (2000 editions).

gypsum, and the presence of free lime or magnesia. There are no test methods to determine the presence and amount of these materials and there are no limits;

8. Clay lumps (CSA A23.2, Test 3A); different limits for coarse and fine;

9. Low-density granular materials (CSA A23.2, Test 4A);

10. Material finer than 80 µm;

11. $MgSO_4$ soundness loss (CSA A23.2, Test 9A); different limits for coarse and fine;

12. Abrasion loss (CSA A23.2, Test 17A); limit for coarse aggregate only;

13. Petrographic examination (CSA A23.1, Clause 5.7); when required by the owner using ASTM C 295; a note to Clause 5.7 states that "ASTM C 294 may be found useful as a guide to the identification of many deleterious substances, including alkali-reactive components";

14. Concrete-making properties (CSA A23.1, Clause 5.8) ("When required by the owner, evidence shall be provided indicating that concrete produced with the proposed aggregates will have the specified strength, density, durability, and volume stability");

15. Aggregate acceptance (CSA A23.1, Clause 5.9); if job specifications require, aggregate should be tested in accordance with one or more of the following tests: ASTM C 666 (freeze-thaw test); ASTM C 671 (critical dilation—test now withdrawn); ASTM C 672 (salt scaling test); and ASTM C 682 (frost resistance—test now withdrawn)

CSA requires most of these tests to be performed on samples of aggregate from each quarry on a yearly basis at a minimum. Furthermore, there are strict guidelines on sampling a source of aggregate to ensure a representative sample is tested.

Notably, there was no requirement to conduct a chemical analysis of the aggregate as of 2002, nor are there any limits imposed on chemical constituents at this time.

Other specifications, such as ASTM C 33 *Standard Specification for Concrete Aggregates*, have similar requirements although methods of test and the criteria used may vary.

Typically aggregate producers will certify aggregates using a third-party laboratory[11] to perform the necessary testing and to issue a certificate of conformance. The different tests may be performed by different laboratories. However, standard practice is to engage a third-party

[11] CSA requires that a laboratory conducting certified tests be accredited by the Canadian Council for Independent Laboratories (CCIL) or a similar accreditation body.

accredited test laboratory and the laboratory will conduct the test and produce a written report indicating whether the aggregate met or failed the limits for the test.

3.2.2. Chemical Composition of Concrete Aggregates

Most rocks are composed predominantly of the eight most abundant elements in the earth's crust; these being oxygen, calcium, silicon, aluminum, iron, magnesium, sodium and potassium. However, the suitability of a rock for use as a concrete aggregate depends primarily on the mineralogy and structure of the rock, rather than on the chemical composition of the rock (that is, the amount of each element present). For example, the vast majority of rocks will contain silica as a minor or major constituent, but this does not reveal anything about the potential for alkali-silica reaction when the rock is used in concrete. It is the mineral form of the silica that determines the degree of reactivity in concrete. For example, olivine ($(Mg,Fe)SiO_4$) is not reactive whereas opal ($SiO_2 \cdot n(H_2O)$) is highly reactive. Well-crystalline quartz (SiO_2) is generally not reactive but microcrystalline, cryptocrystalline or strained quartz may be reactive, despite being of the same chemical composition.

Similarly, sulfur content on its own does not say much about the suitability of an aggregate, as it is critical to know whether the sulfur (S) is present as a sulfide mineral such as pyrite (FeS_2), a sulfate mineral such as thenardite (Na_2SO_4) or as organic sulfur. The form of the sulfur, as well as the amount of the mineral present, determines its impact on concrete.

However, if a chemical analysis indicates a high sulfur content, it does alert the user to the need to perform further testing to elucidate the mineralogy. It should also be noted that knowing the chemical composition can be useful in some cases, such as determining relative amounts dolomite and calcite in a carbonate rock. However, it is far from being sufficient information for determining the suitability of a rock (or sand) for use as an aggregate in concrete, as CSA A23 and other standards make plain.

3.2.3. "Aggregate Evaluation" in the Trois-Rivières Case

In preparing my opinion, regarding the absence of professional services, I took particular note of the following facts, which I understand to be undisputed unless otherwise noted.

In January 2002, Mr. Bergeron, a General Manager at Béton Laurentide, asked Martin Perreault, a Lafarge sales representative with no background in geology,[12] if Lafarge would do a "total sulfur" analysis on a rock sample taken from B&B Quarry.[13] Mr. Perreault retrieved a sample of B&B Quarry aggregate collected by Béton Laurentide and brought it to Lafarge's Corporate Technical Services (CTS) unit.[14]

12 Deposition of Perreault at 22 (Jan. 11, 2017).

13 LAF0000418637 at 188.

14 LAF0000624697 at 147.

Because Lafarge's procedures required CTS personnel to authorize the test, Mr. Perreault asked Ms. de Grosbois to do so. Ms. de Grosbois submitted a request, but never herself possessed the sample.[15]

A laboratory technician at CTS conducted the requested test using an X-ray fluorescence device (XRF), which determined the chemical composition of the sample with respect to its major constituents, and a device known as a LECO SC-432, which detected the quantity of sulfur in the sample.[16]

On February 21, 2002, Mr. Perreault transmitted the results of the test to Mr. Bergeron by fax.[17] The results consisted of a one-page printout showing the quantity of sulfur present in the sample.[18]

On February 22, 2002, Mr. Bergeron called Ms. de Grosbois.[19] Ms. de Grosbois and Mr. Bergeron disagree on what transpired during the phone call.

Mr. Bergeron's notes, allegedly made at that time of the call, state that Ms. de Grosbois recommended conducting more testing.[20] Mr. Bergeron testified that Ms. de Grosbois implied that the "stone was good,"[21] although Ms. de Grosbois disputes this.[22] Ms. de Grosbois further testified that Mr. Bergeron did not ask during the call whether the aggregate was suitable for use in the concrete and that she would have declined to answer that question had it been asked because the test conducted was insufficient to render an opinion on that question.[23]

Mr. Bergeron thereafter communicated with and provided samples of aggregate from B&B Quarry to Dr. Bérubé, a scientist at Laval University and sought from Dr. Bérubé a petrographic analysis of the B&B aggregate.[24] On or about May 4, 2002, Dr. Bérubé disclosed a written document to Mr. Bergeron stating that aggregate from B&B Quarry was of a similar petrographic nature as aggregate from Maskimo Quarry, which was believed to have caused construction defects in the Trois-Rivieres region.[25]

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15 Deposition of de Grosbois at 102 (Feb. 17, 2017).

16 *Id.* at 104, 110.

17 LAF0000631949, attached to this Report as Appendix C.

18 *Id.*

19 Deposition of de Grosbois at 155 (Sept. 23, 2011), LAF0000418883 [Trans.].

20 LAF0000004514

21 Testimony of Bergeron, Vol. 1 at 54, 56 (Apr. 28, 2011), LAF0000827741 [Trans.].

22 Deposition of de Grosbois at 169 (Feb. 17, 2017).

23 *Id.* at 190.

24 Testimony of Bergeron, Vol. 1 at 30-32 (Apr. 28, 2011), LAF0000827741 [Trans.].

25 LAF0000004709 [Trans.].

Mr. Bergeron claims to have faxed Dr. Bérubé's written document to Ms. de Grosbois. Ms. de Grosbois, however, did not communicate with Mr. Bergeron on this subject or take any further action.[26] Indeed, after the telephone conversation between Ms. de Grosbois and Mr. Bergeron on February 22, 2002, neither Ms. de Grosbois nor anyone else at Lafarge conducted further examination or testing on the aggregate from B&B Quarry, or made statements to Béton Laurentide concerning such aggregate, until approximately September 2005.[27]

On September 26, 2005, Ms. de Grosbois and others from Lafarge attended a meeting with representatives of Béton Laurentide. At the meeting, Lafarge agreed to conduct a comparative analysis of rock samples from B&B, Maskimo, and Continental quarries.[28] Ms. de Grosbois and others from Lafarge visited the quarries to observe and collect samples for testing, and Ms. de Grosbois then began conducting her analysis.

3.2.4. Comparison of Lafarge's 2002 Test with a Portion of a Suitability Analysis

Lafarge's brief chemical analysis in February, 2002 of a sample of B&B Quarry aggregate is shown in Appendix C. As can be seen, it consists of a brief numerical statement of sulfur and other constituents of the sample and does not include any analysis, commentary, advice or certification.

In contrast, Appendix D shows a petrographic report analyzing a sample of B&B Quarry aggregate prepared by a Canadian laboratory, Terratech, in 2003. The report states that it follows ASTM C 295, which was the test method referenced in CSA A23.1 in 2000. The report also contains caveats and recommendations for additional analysis. The report is also signed and stamped by a professional geologist.

[redacted]

[redacted]

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26 Testimony of de Grosbois at 235 (Feb. 18, 2013), LAF0000625165 [Trans.].

27 *Id.* at LAF0000625401 [Trans.].

28 LAF0000007513.

4.0 EXPERT OPINION

4.1. [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Temperature is also a factor in controlling the rate of oxidation and, hence, damage accumulation. Above-ground walls with southern exposure likely have a higher average annual temperature. The temperature of walls below ground level will depend on whether basements are heated and the efficiency of any insulation. The factors will combine to give a large variation in the temperature of foundation walls within a house and between houses in the Trois-Rivières area.

For concrete of higher quality (reduced water-to-cementing-materials ratio, increased strength, and lower porosity and permeability) the oxygen and moisture will be transported more slowly but will not be immobilized. The rate of diffusion or permeation of gases, liquids and ionic species in concrete is strongly dependent on the porosity and permeability of the concrete which, in turn, are largely a function of water-to-cementing-material ratio. The W/CM ratio in residential concrete is generally high but also extremely variable due to the practice of adding water on site to adjust the workability of the concrete to account for site conditions.

[redacted]

[redacted]

[redacted]

[redacted].

4.2. Professional Services

My opinion regarding the provision of professional services is as previously stated in Section 2.4 and as follows:

[redacted]

[redacted]

[redacted]

[redacted] It is my opinion that no concrete engineer or geologist would render or purport to render professional advice about the suitability of aggregate solely based on a chemical composition analysis, much less one that was neither certified nor rendered by an accredited laboratory.

It is my opinion also that a professional geologic or engineering services client would not accept purported advice of this nature on the basis of solely these routine tests. In my experience, concrete suppliers and others who seek professional recommendations as to the suitability of building materials, such as aggregates for use in concrete, are typically experienced in obtaining and assessing professional advice. Regarding Canadian concrete suppliers in particular, as the result of their experience with the risks inherent in supplying concrete, such business are necessarily familiar with the types of analysis required before any suitability advice can be rendered, including the Canadian standards for certification of results by an accredited laboratory. I am not aware of any businesses in this area that would be satisfied with a suitability opinion rendered solely on the basis of a routine test for chemical composition, much less one that was neither certified nor rendered by an accredited laboratory.

In my experience regarding professional geologic or concrete engineering services, the use of a written agreement to provide professional services, such as a contract or purchase order, is a reliable indication of intent to provide professional geologic or concrete engineering services, and the absence of such a contract is one indicator that professional services are not to be provided. Setting forth in an agreement the expectations of the parties is standard practice for professional services providers and clients. [redacted]

[redacted]

[redacted]

[redacted]. In my opinion, no geologist or engineer would offer a casual, unwritten recommendation concerning the suitability of a source of aggregate, and particularly not on the basis of a routine sulfur test. In my experience, where professional services are rendered concerning the suitability of aggregate, the persons responsible for providing the advice uniformly detail their recommendations in a written report describing the methodology employed, setting forth and discussing the findings, and including caveats and other considerations.

There are many reasons that professional services providers in this area convey their opinions in writing. Written explanations benefit clients by enabling them to examine the findings and judgments, thus reducing the risk of miscommunication or misinterpretation. Clients can then ask follow-up questions, and ultimately make a considered conclusion as to whether the professional's recommendation is sound. Professionals likewise prefer to deliver their recommendations in writing to ensure that their opinions are complete and correct, to reduce the possibility of confusion or a miscommunication, to persuade their clients that their opinions are sound and considered, and to memorialize important caveats in the event of a dispute or possible liability.

[redacted] As stated above, professional services providers express their opinions in detailed, written fashion (at times accompanied by oral discussions), with the appropriate background information and caveats [redacted]

[redacted] Professional services clients expect detailed written recommendations based upon thorough testing and explanation. Often, written recommendations provide the basis for follow-up questions, conversations, or email exchanges. [redacted]

_________________________	March 20, 2017
Dr. Michael D.A. Thomas	**Date**

EXPERT REPORT OF DR. MICHAEL THOMAS

Lafarge Canada Inc., et al v. American Home Assurance Co., et al., 15-cv-8957

Appendix A

Curriculum Vitae